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Seasonal Carotenoid Variation in American Kestrels

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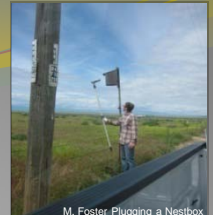
Extracting Carotenoids from Plasma



4 Day Old Nestling



25 Day Old Nestling After Processing



M. Foster Plugging a Nestbox

Abstract

Carotenoids are micronutrient pigments produced by plants that may convey immunological benefits to consumers. Animals with high levels of carotenoid intake may have improved health and higher survival. American Kestrels (*Falco sparverius*) from broods hatched early in the breeding season are more likely to survive and return to the breeding population than birds hatched later in the season. We hypothesized that breeding adults and nestlings may be affected by seasonal patterns in primary productivity that lead to changes in prey quality and availability; therefore affecting carotenoid intake. We collected blood samples from American Kestrels breeding in nestboxes south of Boise, Idaho and measured carotenoid concentrations via spectrophotometry. Our results supported our hypothesis that there are seasonal patterns in carotenoid availability, but trends did not match our predictions. Adult birds did show seasonal declines in carotenoids, while nestlings showed seasonal increases. Further, adult carotenoid levels did not predict nestling levels and there was high annual variation in carotenoid concentrations. Circulating carotenoids may be affected by factors other than food intake (i.e., hormones) making trend difficult to interpret.

Research Framework

- Carotenoids are produced by plants but play an important role in avian biology as antioxidants and skin and feather pigments. Bird color has direct reproductive consequences (Bortolotti et al. 2000).
- American Kestrels hatched early in the breeding season have higher survival and recruitment into the breeding population than birds hatched later in the season (Figure 1).
- The objective of this study was to understand yearly and seasonal variation in carotenoid concentrations. We hypothesized that early breeding birds may benefit from high carotenoid availability and predicted:
 - that adult and nestling carotenoid concentrations would decline throughout the breeding season
 - carotenoid levels in nestling would be positively correlated to concentrations of their parents.
 - there would be little annual variation in carotenoid levels

Variation of Return Rate Determined By Hatching Date

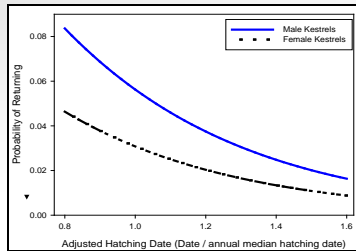


Figure 1. Birds hatched earlier in the season are more likely to return compared to birds hatched later in the season. Males are more likely to return than females (Steenhof and Heath in prep).

Nestling Concentrations Increase as Season Progresses

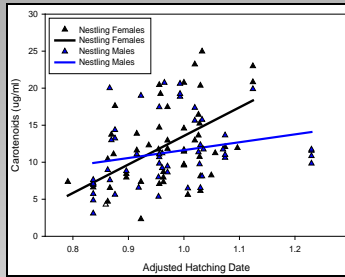


Figure 2. There was a positive relationship between adjusted hatch date and carotenoid concentrations of nestlings.

Adult Concentrations Decline Throughout Season

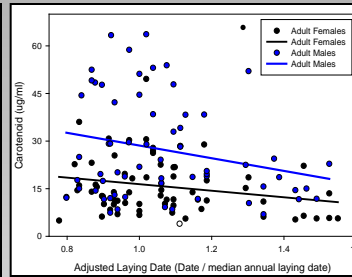


Figure 3. Adult male carotenoid concentrations decreased as the adjusted laying date progressed but there was no significant change for females

Annual Variation of Carotenoid Concentrations

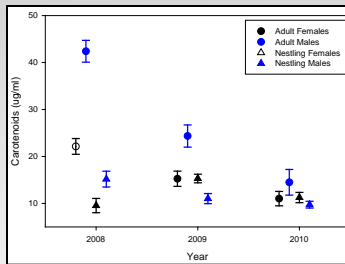
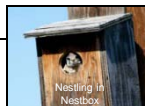


Figure 4. Yearly variations in carotenoid levels (mean and standard error). There were significant differences for adult male and nestling male kestrels, but not females.

Biomedical Implications

Physiological pathways and signals can be highly conserved across vertebrates. Carotenoid pigments can only be synthesized by plants, but may convey immunological, and ecological, benefits to consumers such as mammals and birds. By examining the relationship between carotenoid concentrations and survival of American Kestrels we may begin to understand the physiological benefits of consuming plants high in carotenoid content. Carotenoids may act as an antioxidant in vertebrates because of their efficiency as an antioxidant in plants, though their function may be more complex. Some carotenoids can be classified as a pro-vitamin A or carotenes because humans are able to convert carotenoids into retinol, a vitamin A compound. Vitamin A plays an important role in several physiological functions such as; vision, gene expression, growth and development, red blood cell production, biological functions of zinc and iron, and maintaining skin and mucosal cells of the immune system (Higdon 2003).

Studies have shown both positive and negative relationships of carotenoids and specific types of cancers, mostly lung and prostate. Most studies conclude that higher levels of carotenoids lower the risk of cancer. However, if the subject is already a high risk for lung cancer such as a smoker or asbestos worker, increased levels of the beta-carotene increase the risk of developing the cancer (Higdon 2005).



Nestling in Nestbox

Results

Season vs. Nestling Carotenoids. We found that male and female nestling carotenoids were positively associated with hatching date (nestlings females $P=0.0008$, nestling males $P=0.02$, Figure 2).

Season vs. Adult Carotenoids. We found a negative relationship between adult male carotenoids and egg-laying date ($P=0.01$) but no significant trend for adult females ($P=0.4723$, Figure 3).

Year vs. Nestling Carotenoids. Carotenoid levels of male nestlings were affected by year ($P=0.004$). There was no significant differences for females ($P=0.51$, Figure 4).

Year vs. Adult Carotenoids. There were significant annual differences in carotenoid concentrations for adult males ($P=0.008$), but not adult females ($P=0.097$, Figure 4).

Parent Carotenoids vs. Nestling Carotenoids. We found no significant relationship between the concentrations of parents and nestling carotenoids (all P 's > 0.09).

Discussion

• Our findings supported the hypothesis that carotenoid concentrations in American Kestrels have a seasonal pattern and vary among birds with different breeding phenology. Adult kestrels showed negative correlation between carotenoids and egg-laying date. Both male and female nestlings had strong positive correlations between hatch date and carotenoid concentrations. There was no relationship between parental and nestling carotenoid concentrations.

• The positive pattern of carotenoids and hatch date is opposite of what we predicted based on our understanding of seasonal effects on juvenile recruitment (young hatched early in the season are more likely to return). Interestingly, the adult pattern is consistent. The positive relationship between adult carotenoids and seasonal timing may reflect that adult quality has a strong influence on nestling quality.

• Seasonal declines in carotenoids may indicate a decline in food availability and/or a decline in the quality of breeding birds. As the season progresses reproducing kestrels may spend more energy feeding their young instead of themselves.

• Adult male kestrels tend to have higher carotenoid levels than females. Males may have higher carotenoids because the pigments are being mobilized for soft tissue (bill and cere) coloration that may contribute to mate selection (Bortolotti et al. 2003).

• There were also yearly differences in carotenoids, most likely the result of annual variation in food availability.

Literature Cited

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